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NUCLEAR EMULSION AS NEUTRINO TRACK SENSITIVE TARGET IN THE 15-FOOT BUBBLE CHAMBER

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Nuclear emulsions are particularly well suited as detectors in searches for short lived objects such as charm particles and heavy leptons. Their intrinsically high spatial track resolution should allow direct observation of all decay modes even for proper lifetimes in the region of 10^{-12} to 10^{-15} seconds. It is also recognized that conventional scanning of large emulsion stacks for such interesting rare events is prohibitively laborious and expensive. Localizing the emulsion search area by hybrid detector tagging systems was successfully employed in a variety of cosmic ray experiments, in a neutrino beam test at CERN[1], and is being employed at Fermilab in initial charm particle searches, for neutrino interactions in E-247 and for deep inelastic muon interactions in E-382. In addition to largely eliminating the conventional emulsion scanning, the tagging techniques in the Fermilab experiments also make use of downstream electronic hadronic information and muon spectrometers.

In E-247 the emulsions make up a target of 20 liters, or 0.1 tons, in 6 stacks each 20 x 20 cm in area and 8.3 cm thick in the neutrino beam direction. Tagging and event location is done

with precision wide-gap optical spark chamber methods. A similar search experiment is being prepared at Serpukhov, also using wide-gap spark chambers, with individual emulsion stacks 40 x 40 x 5 cm, all situated at the front of a large neutrino detector and spectrometer[2].

In order to explore further the production of short lived particles by neutrinos, it is of interest to consider how to extend the information content of tagged emulsion techniques. In addition to downstream muon spectrometer information in some form, what is desired is a precise 4π track detector in the immediate vicinity of the emulsions in order to observe and identify as many of the associated particles as possible. Some consideration has already been given[3] to mounting emulsion stacks just in front of the large CERN bubble chambers and using the normal neutrino exposure photographs for locating the emulsion events as well. However, the thick bubble chamber walls and large distances between the sets of tracks in the two detectors reduce the attractiveness of this approach considerably.

To avoid the itervening thick walls, we now consider the possibility of mounting emulsion stacks inside bubble chambers. In principle the photographic process is still operative in bubble chamber liquid environments and emulsion stacks take up very little volume in the large chambers. For heavy liquid warm chambers such as Gargamalle or the simplified chamber modules considered[4] for an electronic spectrometer, a freon mixture which allows operation near room temperature would need to be selected.

For cryogenic bubble chambers such as the 15-foot or the BEBC, the main requirement appears to be the choice of a suitably sensitive large-grain emulsion. Both the NIKFI Type R and Ilford Type G5 emulsions have been demonstrated[5] to be usable at liquid hydrogen temperatures. In particular, specially sensitized NIKFI Type R emulsions have been reported[6] to show track sensitivities of 76 grains per 100 microns at liquid hydrogen temperature as compared to a track density of 87 per 100 microns at room temperature.

Table I lists some estimates for neutrino induced events in the 15-foot chamber (with either a H_2 or D_2 fill, or a rich neon mixture) as well as from track sensitive hydrogen or emulsion targets in the chamber. These estimates are based on the relationship assumed for E-247 and E-310, i.e. an event rate of 3,000 neutrino interactions/ton/10^{18} protons, using 400 GeV protons and wide band double horn system. At the present rate of $\sim 10^{13}$ protons per pulse on the horn target, the numbers in Table I can also be expressed as event rates per 100K pictures run in the 15-foot chamber. These rates are also equivalent to ~10 neutrino events/ton/hour under present Fermilab operating conditions.

Figure 1 illustrates how an emulsion stack TST might be mounted in the nose cone of the 15-foot chamber. The support structure which holds the emulsions should be narrow enough to be installed through the central optics port (18" diameter) before chamber cooldown and for removal as soon as the chamber running period is over. In addition to offering excellent event location and secondary particle identification, the bubble chamber photographs

can help select neutrino interactions by showing whether any tracks occurred in the nose cone upstream of the emulsion target.

For the large 40 liter emulsion TST indicated in Table I and in Figure 1, stack dimensions could be 10 cm in the beam direction, 40 cm vertically and a total of 100 cm horizontally. In practice, a smaller stack of 20 liters (0.1 ton) appears particularly well matched to the geometry of the 15-foot chamber access ports, nose cone and cameras. A small stack of this kind could be used parasitically during several months of bubble chamber experiments with the wide band neutrino beam, accumulating on the order of 1,000 emulsion interactions of exceptional physics interest.

REFERENCES

(1) Burhop, E.H.S. et al. Nuovo Cimento 39, 1037 (1965)

(2) Kaftanov, V., private communication.

(3) Burhop, E.H.S. and M. Conversi, private communications.

(4) Voyvodic, L., Fermilab Report FN-265 (1974).

(5) Barkas, W.H., "Nuclear Research Emulsions" (1963).

(6) Bogomolov, C.S. et al., Second International Conference on Nuclear Photography, Montreal, 1958, p. 124 (1959).

TABLE I

SOME PARAMETERS FOR NEUTRINO INTERACTIONS
IN THE 15-FOOT BUBBLE CHAMBER AND
HYPOTHETICAL TRACK SENSITIVE TARGETS

		CHAMBER LIQUID			TRACK SENSITIVE TARGET	
		H_2	D_2	Ne/H_2	H_2	Emulsion
Volume - Kliters		30	30	30	3	0.04
Mass - Tons		2	4	~20	0.2	0.2
Events/10^{18} proton	ν	6K	12K	60K	600	600
(400 GeV,WB2H)	$\bar{\nu}$	1.5K	3K	60K	150	150